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NRC Meeting: Probabilistic Safety Analysis Overview

May 17th, 2023

Introductions

- NRC Staff
- Holtec Staff

Meeting Agenda

- Introductions
- Purpose and Outcome
- Overview of PSA Quality Control Process
- Overview of Sample Approaches

Purpose and Outcome

PURPOSE: To provide a high-level overview of the SMR-160 PSA modeling approaches and address specific NRC questions related to SMR-160 PSA and design.

OUTCOME: To obtain feedback from the NRC staff on the high-level overview and identify specific topics that the NRC would like to discuss further in future meetings.

Overview of PSA Quality Control Process

- Overview of PSA Quality Control Process
  - Compliance with RG 1.200 requirements
  - Compliance with NUREG-0800 requirements and level of detail
  - Following ANS/ASME Standards, including those “in-process”
    - ASME/ANS RA-Sa-2009 (Lvl 1 Standard Endorsed by RG 1.200)
    - ASME/ANS RA-S-1.1-2022 (Lvl 1 Std Issued May 31, 2022)
    - ANS/ASME-58.22-2014 (LPSD Pilot Standard)
    - ASME/ANS-RA-S-1.2-2019 (DRAFT Updated Level 2 Standard)
  - PSA Groundrules and Assumptions Document (HI-2210453)
  - PSA Model Maintenance Procedure (HPP-160-3112)
  - Gap Assessment(s)

Overview of Sample Approaches

- Initiating Events (HI-2200399 for Level 1 PSA)
  - ✓ Generic
    - Industry Standards (NUREG/CR-5750)
    - Other Plant PSAs (IAEA TECHDOC-749/R)
  - ✓ Plant Specific
    - System Level Review
    - Master Logic Diagram

Overview of Sample Approaches

- Level 1 PSA Accident Sequence Analysis (HI-2200652)
  - Four Primary Considerations for Preventing Core Damage
    - Reactivity Control
    - Short Term Decay Heat Removal
    - Inventory Control
    - Long Term Decay Heat Removal
  - Event Tree Development
    - Use RELAP5-3D to Evaluate Plant Response to each Level 1 Initiating Event
    - Vary available systems/train to support event tree development
    - Verify Event Tree using specific scenarios for each path

Overview of Sample Approaches

- Accident Sequence Analysis
  - Level 2 PSA
    - Group Level 1 Core Damage Sequences into PDS Bins
      - ATWS or Non-ATWS Scenario
      - Bypass or Non-Bypass Scenario
      - RCS Pressure
      - Availability of Long Term Cooling for Low Pressure Scenarios
      - Availability of CVCS Injection for loss of DHR Scenarios
    - Develop Containment Event Tree
    - Use MELCOR for Level 2 PDS Accident Progression
      - Evaluate Containment/Containment System Response
      - Determine maximum pressures, temperatures, timing
      - Determine release characteristics

Overview of Sample Approaches

- Success Criteria
  - ✓ Develop Systems/Trains Required for Each Event Tree Node
  - ✓ Develop System Models based on Success Criteria Determinations

Overview of Sample Approaches

- Systems Analysis
  - ✓ Review of System Design Documents
  - ✓ Discussions with Designers
  - ✓ Identify Data Needs – coordinate with Data analyst
  - ✓ System Level Models Developed and Quantified (~20 Systems)
    - Insights and Design Change Recommendations Provided to Designers
  - ✓ Integrated System Models Developed and Quantified
    - Included Support Systems
    - Insights and Design Change Recommendations Provided to Designers

Overview of Sample Approaches

- Data
  - Generic
    - Initiating Events (NUREG/CR-6928, NUREG-1829, NUREG/CR-5750)
    - Component Types and Failure Modes
    - Common Cause Failures
    - Test & Maintenance
  - Design Specific
    - MELCO DI&C Data

Overview of Sample Approaches

- Human Reliability Analysis
  - Pre-Initiators
    - ASEP Screening Methodology (NUREG/CR-4772)
  - Post-Initiators
    - SPAR-H Methodology (NIREG/CR-6883)
  - Plan is to Update to THERP Methodology (NUREG/CR-1278) when procedures are available

Overview of Sample Approaches

- Integration and Quantification (HI-2210104)
  - ✓ Event trees converted to equivalent fault trees to create one-top model
  - ✓ Top Logic integrated with system level logic based on required success criteria
  - ✓ Quantification (several rounds) performed with cut set reviews at each
    - CDF/LRF level
    - Sequence level
    - Initiating Event level
  - ✓ Risk Significant SSCs Identified – Basis Discussed in Separate Meeting

SSC Parameter	Criteria for Risk Significance Determination
Component level basic event	Conditional CDF $\geq 3 \times 10^{-6}$/yr
System level basic event	Conditional CDF $\geq 1 \times 10^{-5}$/yr
Component level basic event	Conditional LRF $\geq 3 \times 10^{-7}$/yr
System level basic event	Conditional LRF $\geq 1 \times 10^{-6}$/yr
Basic event/contributor	Total FV $\geq$ 0.20

Overview of Sample Approaches

- Uncertainty and Sensitivity (HI-2210105)
  - Epistemic Uncertainty (EPRI 1016737)
  - Aleatory Uncertainty
    - UNCERT
    - 10,000 Samples
    - Monte Carlo Sampling Method
  - Sensitivity Analysis Performed
  - Recommendations for Design Improvement provided to designers

PSA Identified Design Change Suggestions

- PSA Identified Design Changes
  - ✓ [[

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PSA Identified Design Change Suggestions

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PSA Identified Design Change Suggestions

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PSA Identified Design Change Suggestions

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Risk Importance Measures

- Fussell-Vesely (FV), commonly known as fraction of total risk
  - ✓ $FV = \frac{P(top) - P(top \mid A\ success)}{P(top)}$
- Risk Achievement Worth (RAW), or risk increase ratio given a SSC fails
  - ✓ $RAW = \frac{P(top \mid A\ failed)}{P(top)}$
- Conditional CDF (CCDF), or increased CDF when a SSC fails
  - ✓ $CCDF = CDF * RAW$

Industry Guidance

- RG 1.200, RG 1.201 risk-significance criteria
  - FV > 0.005
  - RAW > 2 for a component
  - RAW > 20 for common-cause failures (or system-level events)
- RG 1.174 risk-acceptance guidelines
  - Permanent changes to a plant's licensing basis are considered if calculated ΔCDF is in the range of 10^{-6}/yr to 10^{-5}/yr and total CDF < 10^{-4}/yr
- The ACRS noted that an inappropriately large number of SSCs may be identified as risk-significant using the RG 1.200 criteria for plants with very low estimated CDFs
  - Undue burden on both the licensee and regulatory staff

Need for SMR-160 Thresholds

- Current fleet has a baseline CDF of ~ 1 x 10^{-5}/yr
  - RAW of 2 implies a ΔCDF of 1 x 10^{-5}/yr and CCDF of 2 x 10^{-5}/yr is risk-significant
  - FV of 0.005 implies a CDF contribution of 5 x 10^{-8}/yr is risk-significant
- SMR-160 has a baseline CDF of[[

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SMR-160 Thresholds and Justification

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Preliminary Results

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Conclusion

- SMR-160 developed new risk significance criteria
  - ✓ Consistent with risk significance criteria recently approved by the NRC
- Preliminary results show [[

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Follow-up on NRC Staff Question: "Beyond Design Basis" Winds

- During the 5/3/23 design overview meeting PSA topic, the NRC staff asked how SMR-160 deals with "beyond design basis" winds

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- Does this answer the NRC's question regarding "beyond design basis" winds? If not, can the NRC staff provide further clarification to SMR-160 regarding the question and the definition of "beyond design basis" winds?